NATIONAL ADVISORY COMMITTEE
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TECHNICAL NOTE

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COMPRESSIVE-STRENGTH COMPARISONS OF PANELS HAVING

ALUMINUM-ALLOY SHEET AND STIFFENERS WITH PANELS

HAVING MAGNESIUM-ALLOY SHEET AND

ALUMINUM-ALLOY STIFFENERS

By Norris F. Dow, William A. Hickman,
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Langley Field, Va.

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SUMMARY

Comparisons are made of 24S-T aluminum-alloy flat compression panels having longitudinal Z-section stiffeners and panels having flat FS-1H magnesium-alloy sheet and longitudinal 24S-T aluminum-alloy Z-section stiffeners. These comparisons show that the composite magnesium-alloy, aluminum-alloy panels have the higher structural efficiencies and buckling loads if the stiffeners are widely spaced. If the stiffeners are closely spaced or if the panels have ideal proportions, the comparisons show that the structural efficiencies are very nearly the same except in a small range of loading conditions in which the 24S-T aluminum-alloy panels have slightly higher structural efficiencies. The comparisons also show that the use of the composite magnesium-alloy, aluminum-alloy construction permits wider stiffener spacing with little or no loss in either structural efficiency or stress for local buckling.

INTRODUCTION

A comparison of the properties of magnesium-alloy and aluminum-alloy material, such as the one made in reference 1, indicates that if a structure would buckle at a low compressive load when made of aluminum alloy, it would buckle at a higher load if made of magnesium alloy of the same weight because of the greater bulk of the magnesium alloy. In general, it is to be expected, therefore, that replacing the aluminum-alloy sheet on aluminum-alloy-sheet stiffener panels, which have wide stiffener spacings (hence low buckling loads), with magnesium-alloy sheet of equal weight will increase the load at which the sheet buckles. A construction of this type, having magnesium-alloy sheet and aluminum-alloy stiffeners, is herein referred to as "Mg-Al" construction.

The effect of replacing aluminum-alloy sheet with magnesium-alloy sheet of the same weight on the maximum compressive strength of a panel will depend upon the proportions of the panel. If the proportions are such that failure occurs by column bending at a stress within the elastic range and before any local buckling takes place, little difference in strength between the aluminum-alloy panel and the equivalent Mg-Al panel is to be expected. The increased bulk of the magnesium-alloy sheet offsets its lower modulus, so that the over-all bending stiffness and, therefore, the long-column strength of the Mg-Al panel is about the same as that for the equivalent aluminum-alloy panel.

As the proportions are changed so that failure is accompanied by local buckling or plastic flow of the material, or a combination of these phenomena, it becomes more and more difficult to predict accurately the strength of Mg-Al construction without the aid of experimental data. In order to provide such data, compressive tests were made on Mg-Al panels in the Langley structures research laboratory. The panels tested were essentially replicas of some of the 24S-T aluminum-alloy panels of reference 2, on which the design charts of reference 3 are based, except that the 24S-T sheet was replaced by FS-1H magnesium-alloy sheet of the same weight. The stiffeners were formed of 24S-T aluminum alloy and were of Z-sections of the same basic proportions as those for which the design charts of reference 3 were drawn.

SYMBOLS

P_i compressive load per inch of panel width, kips per inch

c fixity coefficient used in Euler column formula

A_i cross-sectional area per inch of width of a 24S-T
             aluminum-alloy panel, inches

$A_{i_{eq}}$ "equivalent area" per inch of width of Mg-Al panel, inches
             Equivalent area is equal to cross-sectional area of a
             24S-T panel of same weight per unit length as Mg-Al panel.

$\bar{\sigma}_f$ average stress at failing load, ksi

$\bar{\sigma}_{f_{eq}}$ "equivalent average stress at failing load" for a
             Mg-Al panel, or failing load on a Mg-Al panel divided by
             equivalent area of Mg-Al panel, ksi

$t_{S_{eq}}$ thickness of 24S-T aluminum-alloy sheet of same weight as magnesium-alloy sheet in question, inches

σ_{cy} compressive yield stress for material, ksi

$\bar{\epsilon}_f$ unit shortening at failing load

σ_{cr} stress for local buckling, ksi

$\sigma_{cr_{eq}}$ "equivalent stress" for local buckling, ksi

γ weight of material, pounds per cubic inch

b_F width of outstanding flange of stiffener, inches

$b_{F_{adj}}$ width of outstanding flange of stiffener after adjustment has been made to give panel desired cross-sectional area, inches

b_S stiffener spacing of 24S-T panel equivalent to Mg-Al panel, inches; $b_S = \dfrac{b_{S_{adj}}}{1.05}$ for $\dfrac{t_W}{t_{S_{eq}}} = 0.79$ and $b_S = \dfrac{b_{S_{adj}}}{1.06}$

for $\dfrac{t_W}{t_{S_{eq}}} = 1.00$

$b_{S_{adj}}$ stiffener spacing of the Mg-Al panel, inches

t_S sheet thickness, inches

b_W width of web of stiffener, inches

t_W thickness of web of stiffener, inches

b_A width of attachment flange, inches

r_A bend radius for attachment flange, inches

r_F bend radius for outstanding flange, inches

d rivet diameter, inches

p rivet pitch, inches

L   length of panel, inches

W   width of panel, inches

TEST SPECIMENS

Dimensions.- The dimension ratios for the Mg-Al specimens, and the corresponding dimension ratios for the 24S-T aluminum-alloy specimens of references 2 and 3, with which the Mg-Al panels are to be compared, are given in table 1. A typical Mg-Al panel is shown as figure 1 and the panel cross section is shown as figure 2. The Mg-Al panels were made by replacing the 24S-T aluminum-alloy sheet of some of the panels of references 2 and 3 with FS-1E magnesium-alloy sheet of the same weight. There were some differences between the Mg-Al panels and the corresponding 24S-T panels. These differences were as follows:

	Mg-Al	24S-T (references 2 and 3)	Mg-Al	24S-T (references 2 and 3)
Sheet thickness, t_S, in.	0.102	0.064	0.128	0.081
Stiffener spacing, $b_{S_{adj}}$, in.	2.38	- - -	2.98	- - -
	3.40	- - -	4.25	- - -
	5.10	- - -	6.37	- - -
Stiffener spacing, b_S, in.	- - -	2.24	- - -	2.84
	- - -	3.20	- - -	4.05
	- - -	4.80	- - -	6.07
Width of attachment flange, b_A, in.	.61	.52	.61	.60
Bend radius, r_A, in.	.192	.192	.192	.192
Bend radius, r_F, in.	.192	.256	.192	.256

The most striking difference is in the stiffener spacings.
The stiffener spacings for the Mg-Al panels were increased slightly
over the corresponding spacings for the 24S-T panels in order to
make the area per inch of width of the Mg-Al panel such that the
weight of the Mg-Al panel for a given width would be equal to that
for the 24S-T panel. The increases in stiffener spacings were made
because the thickness of magnesium-alloy sheet required to give
weights equivalent to the aluminum-alloy sheet being replaced did
not correspond exactly to the thicknesses available. The magnitude
of these increases in stiffener spacings were approximately 6 percent
for the 0.102-inch-thick magnesium-alloy sheet and 5 percent for the
0.128-inch-thick magnesium-alloy sheet.

Riveting.- The rivets used for the Mg-Al panels were ordinary
A17S-T flat-head rivets (AN442AD) instead of the NACA flush rivets
used on the 24S-T aluminum-alloy panels of references 2 and 3. The
rivet diameters and pitches used are as follows:

	Mg-Al	24S-T (references 2 and 3)	Mg-Al	24S-T (references 2 and 3)
t_s, in.	0.102	0.064	0.128	0.081
d, in.	5/32	1/8	3/16	5/32
p, in.	1/2	3/4	5/8	1

The rivet diameters and pitches used on the Mg-Al panels
were selected in an effort to approach the "potential strengths"
of the panels, that is, the strengths that the panels would develop
if the riveting were strong enough so that further increases in
the strength of riveting would produce no increase in panel strengths.

In order to establish the fact that the differences in riveting
did not reduce the accuracy of the comparison of the Mg-Al panels
and the 24S-T panels, a few additional 24S-T specimens were also
tested. These specimens had 3/16-inch-diameter rivets at 9/16-inch
pitch. This combination of rivet diameter and pitch produced the
strongest panels of all those presented in a paper on the effects
of riveting on panel strength. (See reference 4.)

Material properties.- Maximum, minimum, and average values of
the compressive yield stress for the materials used are as follows:

Compressive yield stress, σ_{cy} (ksi)	Mg-Al		24S-T (from reference 3)
	FS-1H sheet	24S-T stiffeners	24S-T sheet or stiffeners
Maximum	28.0	46.3	46.5
Average	26.5	43.6	44.0
Minimum	25.5	42.0	41.0

The values given for the 24S-T material are representative of the properties of the flat sheet before forming. For the effects of forming on the properties, see reference 5.

METHOD OF TESTING

The panels were tested flat-ended, without side support, in a hydraulic testing machine having an accuracy of one-half of 1 percent of the load. The panels, the ends of which had been ground flat and parallel, were carefully alined in the testing machine so as to insure a uniform distribution of the load over the specimen.

The stress for local buckling was determined by the so-called "strain-reversal" method in which the stress for local buckling corresponds to the stress at which the compressive strain on one side of the sheet begins to be reduced with increasing load. (For a comparison of this method with other methods and with theoretical predictions, see reference 6.)

The unit shortening at maximum load was taken as the average of the strains measured by four $6\frac{1}{2}$-inch gage length resistance-type wire strain gages. These gages were mounted at the quarter point along the length of the panel on both sides of the webs of the second and fifth stiffeners. (See fig. 1.) The over-all shortening of the panel was measured with dial gages as a check on this measurement of unit shortening.

RESULTS

The results are presented on the same type of plot used for the design charts of reference 3 in which $\bar{\sigma}_f$, the average stress at failing load, is plotted against $\dfrac{P_i}{L/\sqrt{c}}$, the ratio of intensity of loading to effective length of panel. The advantage of this type of plot is that $\dfrac{P_i}{L/\sqrt{c}}$ expresses the design conditions, whereas $\bar{\sigma}_f$ is a measure of the structural efficiency. Since $\bar{\sigma}_f$ is load divided by cross-sectional area, the higher $\bar{\sigma}_f$ for a given load per inch P_i, the smaller the cross-sectional area and weight of the panel.

In order to be able to compare directly the structural efficiency of Mg-Al construction with that of 24S-T construction, an "equivalent stress" $\bar{\sigma}_{f_{eq}}$ was computed for the Mg-Al panels by dividing the load carried on the Mg-Al panel by the cross-sectional area of a 24S-T panel of the same weight. It is this value of $\bar{\sigma}_{f_{eq}}$ that is plotted against the design parameter $\dfrac{P_i}{L/\sqrt{c}}$ in figure 3 for the Mg-Al panels. Also plotted in figure 3 for comparison are the values of $\bar{\sigma}_f$ for the strongly riveted 24S-T panels previously mentioned and tested as a part of the present investigation.

From the data presented in figure 3 for Mg-Al panels, a set of design charts (figs. 4 and 5) were prepared. The solid curves plotted in figure 3 were taken from these design charts. The dashed curves for 24S-T panels, also shown in figure 3 for comparison, were taken from the design charts for 24S-T panels of reference 3. Because figure 3 indicates that there is fairly good agreement between the test data for the strongly riveted 24S-T panels and the dashed curves taken from reference 3, direct comparisons between the Mg-Al panels and the 24S-T panels of reference 3, neglecting differences in riveting, should be reasonably reliable.

Numerical values of the test results, including values of unit shortening at maximum load for the Mg-Al and the strongly riveted 24S-T specimens of the present investigation, are given in table 1. All test results have been adjusted in a manner similar

to that used for the results of references 2 and 3 to take into
account the fact that the panels had six stiffeners but only five
widths of sheet between stiffeners. The end-fixity coefficient c
in the tests was assumed to be 3.75, the same value assumed for the
24S-T panels in references 2 and 3.

COMPARISON OF MG-AL AND 24S-T PANELS

A number of possible comparisons can be made between Mg-Al
and 24S-T construction. In the following paragraphs the structural
efficiencies of the two types of construction are compared in three
different ways - direct comparison of test panels, comparison on
the basis of ideal proportions, and comparison of specific minimum
weight designs - and it will be seen that none of these comparisons
show a consistent, substantial advantage of one type over the other.
A fourth, somewhat different comparison, is given in the section
entitled "Application of Mg-Al Construction to Make Wider Stiffener
Spacings Feasible for Smooth Wings."

Panels having the proportions tested.- Since the equivalent
stress $\sigma_{f_{eq}}$ for the Mg-Al panels was defined in such a way as to
be directly comparable with $\bar{\sigma}_f$ for the corresponding 24S-T panels,
figure 3 shows a direct comparison of the structural efficiencies
of the Mg-Al panels tested and the corresponding 24S-T panels for
a given design condition $\dfrac{P_1}{L/\sqrt{c}}$. At low values of $\dfrac{P_1}{L/\sqrt{c}}$, for which
failure occurred principally by column bending, the curves of
figure 3 indicate that there was little or no difference between
the Mg-Al panels and the corresponding 24S-T panels, except when
the 24S-T panels buckled appreciably before failure $\left(\dfrac{b_S}{t_{S_{eq}}} = 75,\right.$
$\left.\dfrac{b_W}{t_W} = 40\right)$, in which case the Mg-Al panels had the higher structural
efficiencies. At intermediate and high values of $\dfrac{P_1}{L/\sqrt{c}}$, the curves
of figure 3 indicate that the Mg-Al panels had the higher
efficiencies, except for the close stiffener spacings $\left(\dfrac{b_S}{t_{S_{eq}}} = 35\right)$
at intermediate values of $\dfrac{P_1}{L/\sqrt{c}}$.

The short horizontal lines representing the buckling stresses in figure 3 show that, as was expected, the Mg-Al panels tested had higher equivalent buckling stresses than the corresponding 24S-T panels at the wide stiffener spacings $\left(\dfrac{b_S}{t_{S_{eq}}} = 50 \text{ or } 75\right)$.

Panels having ideal proportions.- In order to compare Mg-Al and 24S-T panels of ideal proportions, use is made of the design charts of figures 4 and 5 for Mg-Al panels and the design charts of reference 3 for 24S-T panels. These design charts, which represent an elaborate cross-plotting of test data, provide information regarding the structural efficiency of Mg-Al and 24S-T panels of a wide range of proportions. By fairing envelope curves over all the individual curves of the design charts for the Mg-Al panels, a plot of $\bar{\sigma}_{f_{eq}}$ against $\dfrac{P_1}{L/\sqrt{c}}$ can be obtained that represents a series of panels, each of which has the ideal proportions that give the maximum structural efficiency for its particular value of $\dfrac{P_1}{L/\sqrt{c}}$. Envelope curves of this type, for both Mg-Al and 24S-T panels, are presented in figure 6. For no value of $\dfrac{P_1}{L/\sqrt{c}}$ are the envelope curves for the Mg-Al panels in figure 6 above the envelope curves for the 24S-T panels.

At first glance there appears to be a contradiction between the comparison of Mg-Al and 24S-T panels of ideal proportions, and the previous comparison of such panels having the proportions actually tested. Closer inspection of the curves of figure 6, however, reveals that there is little or no difference between the envelope curves for the Mg-Al panels and for the 24S-T panels except for a small range of values of $\dfrac{P_1}{L/\sqrt{c}}$. It might be thought, therefore, that the apparent contradiction between the two methods of comparison was caused by slight differences in fairing the curves of the design charts.

It is possible, however, that a 24S-T panel of ideal proportions for a given value of $\dfrac{P_1}{L/\sqrt{c}}$ is generally more efficient structurally than the ideal Mg-Al panel for the same value of $\dfrac{P_1}{L/\sqrt{c}}$.

It was shown in figure 3 that at the close stiffenor spacings $\left(\dfrac{b_S}{t_{S_{eq}}} = 35\right)$ there was a range of values of $\dfrac{P_i}{L/\sqrt{c}}$ for which the curves from the 24S-T design charts indicated higher structural efficiencies than the curves from the Mg-Al design charts. Comparison of the curves of figures 3 and 6 reveals that it is in this region of close stiffener spacings that the curves of figure 3 most nearly approach the envelope curves for the 24S-T panels. It appears possible, moreover, that there are other close stiffener spacings than $\dfrac{b_S}{t_{S_{eq}}} = 35$ for which 24S-T panels have a range of higher structural efficiencies than Mg-Al panels. It is also possible that at these close stiffener spacings the ideal proportions are achieved. Ideally proportioned panels, as was pointed out in reference 3, generally have close stiffener spacings.

    <u>Panels having the proportions required for specific minimum weight designs</u>. - Because of certain restrictions, such as the fact that sheet material is available in only a limited number of thicknesses, it is seldom possible to achieve the ideal proportions in an actual design. Consequently, comparisons of panels having the proportions required by specific designs are usually of greater significance than comparisons of panels having ideal proportions.

    In order to compare Mg-Al and 24S-T panels having the proportions required for specific minimum weight designs, the charts of figures 4 and 5 and the procedure of the appendix were used to make comparative designs of Mg-Al panels for all three lengths (L = 10 in., 20 in., and 30 in.) covered by the sample 24S-T designs of reference 3. Because there are Mg-Al panel design charts for only two values of the ratio of sheet thickness to stiffener thickness $\left(\dfrac{t_W}{t_{S_{eq}}} = 0.79 \text{ and } 1.00\right)$ the comparative designs were restricted to only those values of the thickness ratio. The remaining design requirements were the same as those used in reference 3, namely;

$$P_i = 3.0 \text{ kips/inch}$$

$$t_{S_{eq}} = 0.064 \text{ inch}$$

$$c = 1$$

These comparative designs are presented in figure 7, together
with the corresponding 24S-T designs from reference 3.

For both values of $\dfrac{t_W}{t_{S_{eq}}}$, and for all three lengths, figure 7

shows that the Mg-Al panel designs have wider stiffener spacings
than the 24S-T panel designs. Despite their wider stiffener spacings,
the Mg-Al panels have higher equivalent buckling stresses than the
24S-T panels, as shown by the bar graphs in figure 7, except for
one case in which the stiffener spacing was the closest of any
of these comparative designs, and in this case the buckling stresses
were essentially the same. The bar graphs also show that the Mg-Al
panels are slightly lighter in weight (that is, carry a higher
equivalent stress $\bar{\sigma}_{f_{eq}}$ at the design load) than the 24S-T panels,
except for the design having the closest stiffener spacing, in
which case the weights were also essentially the same.

The comparative designs in figure 7 show that the Mg-Al panels
vary with the specific design requirements from 4.8 percent lighter
to 2.2 percent heavier than the 24S-T panels. If it is desired to
know whether a Mg-Al or a 24S-T panel will be the lighter for a
given application, comparative minimum weight designs of both Mg-Al
and 24S-T panels should therefore be made from their respective
design charts to meet the given requirements.

APPLICATION OF MG-AL CONSTRUCTION TO

MAKE WIDE STIFFENER SPACINGS FEASIBLE

FOR SMOOTH WINGS

The foregoing discussion indicates no consistent, substantial
difference in structural efficiency between 24S-T and Mg-Al construc-
tion. Because Mg-Al panels have generally higher buckling stresses,
however, it seems likely that they would provide smooth surfaces
up to high load factors at wider stiffener spacings than would
24S-T panels. In reference 3, it was pointed out that panels designed
for maximum structural efficiency have buckling loads quite close to
the maximum load, but that such panels would require rather close
stiffener spacings (thus also a large number of rivets). Experience
in the use of the design charts of reference 3 indicates that wider
spacings can be used with relatively small losses in structural
efficiency but result in a substantial decrease of the buckling stress.
If Mg-Al construction were substituted for 24S-T, the buckling stress

could presumably be raised to a reasonable value and the wider spacing could be maintained with little or no losses in structural efficiency.

In order to show how Mg-Al construction permits wider stiffener spacing, figure 8 was prepared. In this figure the values of $\bar{\sigma}_f$ $\left(\text{or } \bar{\sigma}_{f_{eq}}\right)$ and σ_{cr} $\left(\text{or } \sigma_{cr_{eq}}\right)$ for the comparative designs of figure 7 are plotted against the stiffener spacing b_s. It is evident from the figure that the Mg-Al designs allow appreciably wider stiffener spacings than the 24S-T designs with little or no losses in either buckling stresses or average stresses at maximum load.

CONCLUSIONS

Comparisons of 24S-T aluminum-alloy flat compression panels having longitudinal Z-section stiffeners and panels having flat FS-1H magnesium-alloy sheet and longitudinal 24S-T aluminum-alloy Z-section stiffeners showed that:

(1) If the stiffeners were widely spaced, the composite magnesium-alloy, aluminum-alloy panels had the higher structural efficiencies and buckling loads.

(2) If the stiffeners were closely spaced or if the panels had ideal proportions the structural efficiencies were very nearly the same, except in a small range of loading conditions for which the 24S-T panels had slightly higher structural efficiencies.

(3) A consideration of the characteristics of the Mg-Al construction indicated that it could be used to permit considerably wider stiffener spacings than 24S-T aluminum-alloy construction with little or no loss in either structural efficiency or stress for local buckling.

Langley Memorial Aeronautical Laboratory,
    National Advisory Committee for Aeronautics,
        Langley Field, Va., January 20, 1947.

APPENDIX

The procedure used for making the sample designs presented in figure 7 is taken from reference 3, except that changes and additions have been made to take into account the difference in density of the Mg-Al construction. This procedure is as follows: (The values for $L = 20$ and $\dfrac{t_W}{t_{S_{eq}}} = 0.79$ are given in table 2 and are referenced to the steps in the following procedure.)

(1) Compute $\dfrac{P_i}{L/\sqrt{c}}$.

(2) From the curves for a particular value of $\dfrac{t_W}{t_{S_{eq}}}$ (in the example, fig. 4 for $\dfrac{t_W}{t_{S_{eq}}} = 0.79$ is used) pick off for each value of $\dfrac{b_W}{t_W}$ and $\dfrac{b_S}{t_{S_{eq}}}$ the value of $\bar\sigma_{f_{eq}}$ corresponding to the value of $\dfrac{P_i}{L/\sqrt{c}}$.

(3) Pick from table 3 or 4 the values of $\dfrac{A_{i_{eq}}}{t_{S_{eq}}}$ corresponding to the ratios used in step (2).

(4) Compute

$$t_{S_{eq}} = \frac{P_i}{\bar\sigma_{f_{eq}} \dfrac{A_{i_{eq}}}{t_{S_{oq}}}}$$

(5) Plot $t_{S_{eq}}$ and $\bar\sigma_{f_{eq}}$ against $\dfrac{b_S}{t_{S_{eq}}}$ for each value of $\dfrac{b_W}{t_W}$ and $\dfrac{t_W}{t_{S_{eq}}}$. Plot the particular value of $\dfrac{b_W}{t_W}$ at the value of $\dfrac{b_S}{t_{S_{eq}}}$ for which $t_{S_{eq}}$ equals the specified value, and mark the

value of stress at that value of $\dfrac{b_S}{t_{S_{eq}}}$.

(6) After step (5) has been completed for all the values of $\dfrac{b_W}{t_W}$, draw curves of stress and of $\dfrac{b_W}{t_W}$ against $\dfrac{b_S}{t_{S_{eq}}}$ through the points determined in step (5).

(7) Each of the curves drawn in step (6) represents a series of designs, all of which have the required value of $t_{S_{eq}}$ (in this case 0.064 in.). The maximum point on the curve of $\bar{\sigma}_{f_{eq}}$ indicates the design for maximum structural efficiency for the particular value of $\dfrac{t_W}{t_{S_{eq}}}$. Note this maximum value of $\bar{\sigma}_{f_{eq}}$, the value of $\dfrac{b_S}{t_{S_{eq}}}$ at which it is reached, and the value of $\dfrac{b_W}{t_W}$, which can be picked from the curve of $\dfrac{b_W}{t_W}$ against $\dfrac{b_S}{t_{S_{eq}}}$.

(8) Make an approximate check of computations by picking from table 3 or 4 the value of $\dfrac{A_{1_{eq}}}{t_{S_{eq}}}$ corresponding to the ratios selected for maximum structural efficiency in step (7). If all computations and plots are correct,

$$P_1 = \bar{\sigma}_{f_{eq}} \frac{A_{1_{eq}}}{t_{S_{eq}}} t_{S_{eq}}$$

(9) Compute the panel dimensions,

$$t_S = \frac{t_{S_{eq}}}{0.64} \quad \text{(to nearest sheet gage)}$$

$$t_W = \frac{t_W}{t_{S_{eq}}} \, t_{S_{eq}}$$

$$b_{S_{adj}} = \frac{b_S}{t_{S_{eq}}} \, t_{S_{eq}} \, (1.05) \ \text{for} \ \frac{t_W}{t_{S_{eq}}} = 0.79$$

or

$$b_{S_{adj}} = \frac{b_S}{t_{S_{eq}}} \, t_{S_{eq}} \, (1.06) \ \text{for} \ \frac{t_W}{t_{S_{eq}}} = 1.00$$

$$b_W = \frac{b_W}{t_W} \, t_W$$

$$b_A = \frac{b_A}{t_W} \, t_W$$

$$r_A = \frac{r_A}{t_W} \, t_W \quad \text{where} \ \frac{r_A}{t_W} = 3$$

$$r_F = \frac{r_F}{t_W} \, t_W \quad \text{where} \ \frac{r_F}{t_W} = 3$$

$$b_F = \frac{b_F}{b_W} \, b_W$$

The values of 1.05 and 1.06 given for computing $b_{S_{adj}}$ are to take account of the fact that the gages of magnesium-alloy sheet are not in exactly the same ratio to the equivalent gages of 24S-T aluminum-alloy sheet as the ratio of densities. The value of $A_{1_{eq}}$ obtained by this method may vary by 1 or 2 percent from the true value; the magnitude of the variation depends upon the proportions and the absolute dimensions. If the sheet thickness is large enough so that

it is determined as a fraction of an inch instead of as a wire gage, the actual value of $A_{1_{eq}}$ may vary more than 2 percent from the value given by the preceding computation. In any case the best procedure is to check the true value of $A_{1_{eq}}$.

(10) Check the true value of $A_{1_{eq}}$ of the design.

$$A_{1_{eq}} = 0.64 t_S + \left[b_W + b_F + b_A - \left(2 - \frac{\pi}{2} \right) (r_A + r_F + t_W) \right] \frac{t_W}{b_{S_{adj}}}$$

(11) Compute the value of $A_{1_{eq}}$ required to carry the load at the determined value of $\bar{\sigma}_{f_{eq}}$ as

$$A_{1_{eq(required)}} = \frac{P_1}{\bar{\sigma}_{f_{eq}}}$$

If the value of $A_{1_{eq}}$ determined from step (10) is different from the required value calculated in step (11), an adjustment may be made by slight changes in the width of the outstanding flanges of the stiffeners. Reference 3 pointed out that variations in width of the outstanding flange from $\frac{b_F}{b_W} = 0.3$ to $\frac{b_F}{b_W} = 0.5$ did not affect the panel strength. This adjustment is usually unnecessary as the given procedure in most cases yields a sufficiently accurate value of $A_{1_{eq}}$. The value of $A_{1_{eq}}$ determined by the design procedure for the case given in table 2 is 0.1019 inch, for example, and the value of $A_{1_{eq}}$ required to give a stress of 29.5 ksi at $P_1 = 3.0$ kips/inch is 0.1017 inch.

(12) If desired, however, the adjusted value of b_F, needed to give the exact value of $A_{1_{eq}}$ required, may be computed from the following formula:

$$b_{F_{adj}} = \frac{\left(A_{1_{eq(required)}} - 0.64 t_S \right) b_{S_{adj}}}{t_W} - b_A$$

$$+ \left(2 - \frac{\pi}{2} \right) (r_A + r_F + t_W) - b_W$$

(13) Obtain $\sigma_{cr_{eq}}$ from the design charts by interpolation for the proportions determined.

(14) Repeat steps (2) to (13) for the other value of $t_W/t_{S_{eq}}$.

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6. Hu, Pai C., Lundquist, Eugene E., and Batdorf, S. B.: Effect
   of Small Deviations from Flatness on Effective Width and
   Buckling of Plates in Compression. NACA TN No. 1124, 1946.

TABLE 1.- PROPORTIONS OF SPECIMENS AND TEST DATA

Proportions of 24S-T panels										Test data for 24S-T panels (a)			Proportions of Mg-Al panels										Test data for Mg-Al panels			
$\frac{t_W}{t_S}$	$\frac{b_S}{t_S}$	$\frac{b_W}{t_W}$	$\frac{b_F}{b_W}$	$\frac{b_A}{t_W}$	$\frac{r_F}{t_W}$	$\frac{r_A}{t_W}$	$\frac{d}{t_S}$	$\frac{p}{t_S}$	$\frac{L}{b_W}$ (b)	σ_{cr} (ksi)	$\bar\sigma_f$ (ksi)	$\frac{P_1}{L\sqrt{\sigma}}$ $\left(\frac{kips/in}{in.}\right)$	$\frac{t_W}{t_S}$	$\frac{b_S}{t_S}$	$\frac{b_W}{t_W}$	$\frac{b_F}{b_W}$	$\frac{b_A}{t_W}$	$\frac{r_F}{t_W}$	$\frac{r_A}{t_W}$	$\frac{d}{t_S}$	$\frac{p}{t_S}$	$\frac{L}{b_W}$ (b)	$q_{r_{eq}}$ (ksi)	$\sigma_{f_{eq}}$ (ksi)	$\frac{P_1}{L\sqrt{\sigma}}$ $\left(\frac{kips/in}{in.}\right)$	$\bar\tau_f$
1.00	35	20	0.4	8.3	4	3	1.95	11.7	----	----	----	----	0.63	23.3	20	0.4	9.6	3	3	1.53	4.9	7.9	----	42.8	1.060	5250 × 10⁶
									16.0	----	36.7	0.418										15.7	----	40.5	.492	4780
									28.0	----	33.7	.222										27.6	----	32.1	.223	3440
									----	----	----	----										47.2	----	20.7	.083	2050
		30							----	----	----	----			30							8.2	----	38.3	.719	4690
									16.7	32.4	33.3	.291										16.4	----	35.8	.335	3960
									28.7	----	31.6	.163										28.6	----	31.4	.167	3320
									----	----	----	----										49.1	----	21.0	.065	2010
															40							8.3	21.5	31.0	.490	3570
																						16.5	----	28.2	.227	3250
																						28.9	----	23.1	.108	2330
																						49.5	----	17.6	.048	1750
	50	20							----	----	----	----		33.3	20							7.5	34.5	35.9	.805	4570
									15.1	18.8	31.6	.322										15.0	----	36.1	.391	3740
									26.3	18.0	29.1	.167										26.2	----	32.6	.202	3250
									----	----	----	----										44.9	----	20.7	.076	2000
		30							----	----	----	----			30							7.9	33.5	34.6	.567	3930
									16.3	18.9	29.0	.218										15.9	----	34.1	.273	3790
									28.5	17.8	27.5	.120										27.8	----	30.4	.138	3180
									----	----	----	----										47.6	----	23.9	.064	2290
															40							8.1	24.0	28.6	.381	3050
																						16.2	27.5	28.8	.192	3120
																						28.4	----	23.5	.089	2440
																						48.7	----	19.1	.043	1900
	75	20							----	----	----	----		50.0	20							6.9	18.1	29.3	.619	7330
									14.3	9.7	25.9	.245										13.8	17.0	28.3	.293	5500
									24.9	8.4	23.8	.128										24.2	18.0	26.6	.158	3790
									----	----	----	----										41.4	18.5	19.3	.067	1930
		30							----	----	----	----			30							7.5	16.1	28.4	.413	4340
									15.1	8.0	24.2	.160										15.0	17.2	27.1	.193	3980
									26.6	8.8	22.8	.086										26.2	18.8	25.9	.106	3030
									----	----	----	----										45.0	16.7	19.9	.047	2050
															40							7.8	17.0	25.7	.296	----
																						15.6	17.4	23.9	.136	3640
																						27.3	18.0	21.9	.071	2440
																						46.7	----	18.9	.036	1920

a From references 2 and 3.
b The panel lengths given are those for the actual test specimens for which c ≈ 3.75

TABLE 1.- PROPORTIONS OF SPECIMENS AND TEST DATA - Continued

Proportions of 24S-T panels										Test data for 24S-T panels (a)			Proportions of Mg-Al panels										Test data for Mg-Al panels			
$\frac{t_W}{t_S}$	$\frac{b_S}{t_S}$	$\frac{b_W}{t_W}$	$\frac{b_F}{b_W}$	$\frac{b_A}{t_W}$	$\frac{r_F}{t_W}$	$\frac{r_A}{t_W}$	$\frac{d}{t_S}$	$\frac{p}{t_S}$	$\frac{L}{b_W}$ (b)	σ_{cr} (ksi)	σ_f (ksi)	$\frac{P_i}{L\sqrt{\bar{c}}}$ (kips/in / in.)	$\frac{t_W}{t_S}$	$\frac{b_S}{t_S}$	$\frac{b_W}{t_W}$	$\frac{b_F}{b_W}$	$\frac{b_A}{t_W}$	$\frac{r_F}{t_W}$	$\frac{r_A}{t_W}$	$\frac{d}{t_S}$	$\frac{p}{t_S}$	$\frac{L}{b_W}$ (b)	$\sigma_{cr_{eq}}$ (ksi)	$\bar{\sigma}_{f_{eq}}$ (ksi)	$\frac{P_i}{L\sqrt{\bar{c}}}$ (kips/in / in.)	$\bar{\tau}_f$
0.79	35	20	0.4	9.4	4	3	1.93	12.3	----	----	----	----	0.50	23.3	20	0.4	9.6	3	3	1.46	4.9	7.4	----	40.4	1.084	4860 × 10⁶
									15.1	27.4	35.7	0.472										14.8	----	40.0	.528	4880
									26.8	----	34.6	.265										25.9	----	30.6	.230	3160
									----	----	----	----										44.5	----	----	----	----
		30							----	----	----	----			30							7.9	----	36.9	.715	4250
									15.1	----	32.5	.313										15.8	33.5	35.6	.347	3925
									27.9	----	31.7	.173										27.6	----	30.5	.169	3170
									----	----	----	----										47.3	----	21.7	.070	2140
															40							8.1	24.3	32.6	.522	3430
																						16.1	22.0	30.0	.236	3220
																						28.2	23.2	24.6	.111	2460
																						48.5	----	19.1	.050	2060
	50	20							----	----	----	----		33.2	20							6.9	33.0	33.8	.880	3920
									14.0	16.9	29.6	.374										13.8	33.7	34.1	.448	4020
									24.6	19.0	27.2	.194										24.1	33.0	34.2	.253	3730
									----	----	----	----										41.2	----	20.8	.090	2100
		30							----	----	----	----			30							7.5	32.0	33.6	.599	3680
									15.1	18.6	27.6	.238										15.0	32.3	32.4	.295	3410
									26.4	20.1	26.8	.134										26.2	30.0	30.2	.152	3100
									----	----	----	----										44.8	----	22.0	.064	2205
															40							7.8	24.5	28.3	.415	2880
																						15.5	24.5	29.1	.205	3000
																						27.2	----	24.1	.097	2480
																						46.6	----	20.5	.048	2070
	75	20							----	----	----	----		49.8	20							6.2	18.5	29.6	.902	5780
									12.7	9.7	24.7	.313										12.4	----	26.4	.339	4410
																							18.5	25.3	.337	5750
									22.0	9.1	23.1	.168										21.6	16.5	26.0	.192	3120
									----	----	----	----										37.1	16.7	18.2	.078	1870
		30							----	----	----	----			30							6.9	17.5	27.2	.476	4080
									14.1	9.0	23.6	.158										13.7	14.5	26.8	.231	4320
									24.9	9.0	21.6	.102										24.0	16.5	25.4	.123	3310
									----	----	----	----										41.1	15.5	18.6	.053	1860
															40							7.3	13.0	24.2	.312	2960
																						14.5	17.5	24.1	.155	2940
																						25.4	17.5	23.2	.086	2610
																						43.5	17.8	19.3	.041	1900

[a]From references 2 and 3.
[b]The panel lengths given are those for the actual test specimens for which c ≈ 3.75

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TABLE 1.- PROPORTIONS OF SPECIMENS AND TEST DATA - Concluded

Proportions of strongly riveted 24S-T panels										Test data for strongly riveted 24S-T panels		
$\dfrac{t_W}{t_S}$	$\dfrac{b_S}{t_S}$	$\dfrac{b_W}{t_W}$	$\dfrac{b_F}{b_W}$	$\dfrac{b_A}{t_W}$	$\dfrac{r_F}{t_W}$	$\dfrac{r_A}{t_W}$	$\dfrac{d}{t_S}$	$\dfrac{p}{t_S}$	$\dfrac{L}{b_W}$ (a)	$\bar{\sigma}_f$ (ksi)	$\dfrac{P_1}{L/\sqrt{c}}$ $\left(\dfrac{\text{kips/in}}{\text{in.}}\right)$	$\bar{\epsilon}_f$
1.00	35	20	0.4	9.6	3	3	2.93	8.8	7.7	37.8	0.940	5800×10^6
									15.4	37.3	.472	6250
									26.9	34.1	.247	3580
									----	----	----	----
		30							8.0	36.1	.675	4380
									16.1	34.8	.335	3660
									28.0	29.7	.157	2970
									----	----	----	----
		40							8.1	29.8	.486	3110
									16.2	27.5	.224	----
									28.4	23.5	.110	2360
									----	----	----	----
	50	20							7.3	34.5	.782	6870
									14.5	33.0	.379	7800
									25.4	28.5	.186	3410
									----	----	----	----
		30							7.7	30.5	.497	4360
									15.5	29.5	.239	4500
									27.1	27.0	.124	2910
									----	----	----	----
		40							7.8	26.5	.362	3500
									15.7	25.1	.172	2690
									27.5	23.1	.091	2220
									----	----	----	----
	75	20							6.6	28.1	.588	7210
									13.2	26.3	.278	5690
									23.2	23.9	.143	3610
									----	----	----	----
		30							7.2	26.3	.378	4470
									14.5	25.3	.182	4750
									25.5	23.7	.097	3320
									----	----	----	----
		40							7.6	23.2	.267	----
									15.2	22.3	.128	3120
									26.6	19.8	.065	2500
									----	----	----	----

[a] The panel lengths given are those for the actual test specimens for which $c \approx 3.75$

TABLE 2.- VALUES AND COMPUTATIONS FOR OBTAINING DESIGN OF MG-AL PANEL

$$P_1 = 3.0 \text{ kips/in.}; \quad L = 20 \text{ in.}; \quad c = 1; \quad t_{S_{eq}} = 0.064 \text{ in.}; \quad \frac{t_W}{t_{S_{eq}}} = 0.79; \quad \text{discussion of steps in appendix}$$

Step 1	Step 2			Step 3	Step 4	Step 7			Step 8		Step 9						Step 10	Step 11	Step 12	Step 13
$\frac{P_1}{L/\sqrt{c}}$ $\left(\frac{\text{kips/in}}{\text{in.}}\right)$	$\frac{b_W}{t_W}$	$\frac{b_B}{t_{S_{eq}}}$	$\bar{\sigma}_{f_{eq}}$ (ksi)	$\frac{A_{1_{eq}}}{t_{S_{eq}}}$	$t_{S_{eq}}$ (in.)	$\frac{b_B}{t_{S_{eq}}}$	$\frac{b_W}{t_W}$	$\bar{\sigma}_{f_{eq}}$ (ksi)	$\frac{A_{1_{eq}}}{t_{S_{eq}}}$	P_1 (kips/in)	t_W (in.)	$b_{S_{adj}}$ (in.)	b_W (in.)	b_A (in.)	$r_A - r_F$ (in.)	b_F (in.)	$A_{1_{eq}}$ (in.)	$A_{1_{eq}}$ (required) (in.)	$b_{F_{adj}}$ (in.)	$\sigma_{cr_{eq}}$ (ksi)
0.15	25	35	28.4	1.738	0.0608	47	27	29.5	1.587	3.0	0.051	3.16	1.378	0.490	0.153	0.551	0.1019	0.1017	0.544	29.5
		40	28.9	1.645	.0631															
		50	29.0	1.516	.0683															
		60	27.5	1.430	.0764															
		75	24.9	1.344	.0896															
	30	35	29.4	1.862	.0548															
		40	29.7	1.755	.0576															
		50	29.3	1.604	.0638															
		60	28.0	1.503	.0712															
		75	25.5	1.402	.0839															
	35	35	28.1	1.987	.0537															
		40	28.4	1.864	.0567															
		50	28.3	1.692	.0626															
		60	27.0	1.576	.0705															
		75	24.7	1.461	.0831															
	40	40	26.9	1.973	.0565															
		50	26.6	1.778	.0635															
		60	25.5	1.649	.0713															
		75	23.5	1.519	.0840															

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TABLE 3.- VALUES OF A_1/t_S FOR FLAT PANELS WITH Z-SECTION STIFFENERS HAVING

$\dfrac{h_T}{b_W} = 0.4$ (FROM REFERENCE 3) FOR USE AS VALUES OF $A_{1_{eq}}/t_{S_{eq}}$ WITH

DESIGN CHARTS FOR MG-AL PANELS HAVING $\dfrac{t_W}{t_{S_{eq}}} = 0.79$

b_S/t_S \ b_W/t_W	20	21	22	23	24	25	26	27	28	29	30	32	34	36	38	40	42	44	46	48	50
25	1.858	1.893	1.928	1.963	1.998	2.033	2.068	2.103	2.138	2.172	2.207	2.277	2.347	2.417	2.487	2.557	2.627	2.697	2.767	2.836	2.906
26	1.825	1.859	1.892	1.926	1.959	1.993	2.027	2.060	2.094	2.127	2.161	2.228	2.295	2.363	2.430	2.497	2.564	2.631	2.699	2.766	2.833
27	1.794	1.827	1.859	1.891	1.924	1.956	1.989	2.021	2.053	2.086	2.118	2.183	2.247	2.312	2.377	2.442	2.506	2.571	2.636	2.700	2.765
28	1.766	1.797	1.828	1.860	1.891	1.922	1.953	1.984	2.016	2.047	2.078	2.140	2.203	2.265	2.328	2.390	2.453	2.515	2.577	2.640	2.702
29	1.740	1.770	1.800	1.830	1.860	1.890	1.920	1.950	1.981	2.011	2.041	2.101	2.161	2.222	2.282	2.342	2.402	2.463	2.523	2.583	2.643
30	1.715	1.744	1.773	1.802	1.831	1.861	1.890	1.919	1.948	1.977	2.006	2.064	2.123	2.181	2.239	2.297	2.356	2.414	2.472	2.530	2.589
31	1.692	1.720	1.748	1.776	1.805	1.833	1.861	1.889	1.917	1.946	1.974	2.030	2.086	2.143	2.199	2.256	2.312	2.368	2.425	2.481	2.537
32	1.670	1.698	1.725	1.752	1.779	1.807	1.834	1.861	1.889	1.916	1.943	1.998	2.053	2.107	2.162	2.216	2.271	2.326	2.380	2.435	2.489
33	1.650	1.676	1.703	1.729	1.756	1.782	1.809	1.835	1.862	1.888	1.915	1.968	2.021	2.074	2.127	2.179	2.232	2.285	2.338	2.391	2.444
34	1.631	1.657	1.682	1.708	1.734	1.759	1.785	1.811	1.836	1.862	1.888	1.939	1.991	2.042	2.093	2.145	2.196	2.248	2.299	2.350	2.402
35	1.613	1.638	1.663	1.688	1.713	1.738	1.763	1.788	1.812	1.837	1.862	1.912	1.962	2.012	2.062	2.112	2.162	2.212	2.262	2.312	2.362
36	1.596	1.620	1.644	1.669	1.693	1.717	1.741	1.766	1.790	1.814	1.838	1.887	1.936	1.984	2.033	2.081	2.130	2.178	2.227	2.275	2.324
37	1.580	1.603	1.627	1.650	1.674	1.698	1.721	1.745	1.769	1.792	1.816	1.863	1.910	1.957	2.005	2.052	2.099	2.146	2.194	2.241	2.288
38	1.564	1.587	1.610	1.633	1.656	1.679	1.702	1.725	1.748	1.771	1.794	1.840	1.886	1.932	1.978	2.024	2.070	2.116	2.162	2.208	2.254
39	1.550	1.572	1.595	1.617	1.640	1.662	1.684	1.707	1.729	1.752	1.774	1.819	1.864	1.908	1.953	1.998	2.043	2.088	2.132	2.177	2.222
40	1.536	1.558	1.580	1.602	1.624	1.645	1.667	1.689	1.711	1.733	1.755	1.798	1.842	1.886	1.929	1.973	2.017	2.060	2.104	2.148	2.192
42	1.511	1.531	1.552	1.573	1.594	1.615	1.635	1.656	1.677	1.698	1.719	1.760	1.802	1.844	1.885	1.927	1.968	2.010	2.052	2.093	2.135
44	1.487	1.507	1.527	1.547	1.567	1.587	1.607	1.626	1.646	1.666	1.686	1.726	1.765	1.805	1.845	1.885	1.924	1.964	2.004	2.043	2.083
46	1.466	1.485	1.504	1.523	1.542	1.561	1.580	1.599	1.618	1.637	1.656	1.694	1.732	1.770	1.808	1.846	1.884	1.922	1.960	1.998	2.036
48	1.447	1.465	1.483	1.501	1.520	1.538	1.556	1.574	1.592	1.611	1.629	1.665	1.702	1.738	1.774	1.811	1.847	1.884	1.920	1.956	1.993
50	1.429	1.446	1.464	1.481	1.499	1.516	1.534	1.551	1.569	1.586	1.604	1.639	1.674	1.709	1.743	1.778	1.813	1.848	1.883	1.918	1.953
52	1.412	1.429	1.446	1.463	1.480	1.496	1.513	1.530	1.547	1.564	1.580	1.614	1.648	1.681	1.715	1.748	1.782	1.816	1.849	1.883	1.917
54	1.397	1.413	1.430	1.446	1.462	1.478	1.494	1.510	1.527	1.543	1.559	1.591	1.624	1.656	1.688	1.721	1.753	1.786	1.818	1.850	1.883
56	1.383	1.399	1.414	1.430	1.445	1.461	1.477	1.492	1.508	1.523	1.539	1.570	1.601	1.633	1.664	1.695	1.726	1.757	1.789	1.820	1.851
58	1.370	1.385	1.400	1.415	1.430	1.445	1.460	1.475	1.490	1.505	1.520	1.551	1.581	1.611	1.641	1.671	1.701	1.731	1.761	1.792	1.822
60	1.357	1.372	1.387	1.401	1.416	1.430	1.445	1.459	1.474	1.489	1.503	1.532	1.561	1.590	1.620	1.649	1.678	1.707	1.736	1.765	1.794
65	1.330	1.343	1.357	1.370	1.384	1.397	1.411	1.424	1.438	1.451	1.464	1.491	1.518	1.545	1.572	1.599	1.626	1.653	1.679	1.706	1.733
70	1.306	1.319	1.331	1.344	1.356	1.369	1.381	1.394	1.406	1.419	1.431	1.456	1.481	1.506	1.531	1.556	1.581	1.606	1.631	1.656	1.681
75	1.286	1.298	1.309	1.321	1.333	1.344	1.356	1.368	1.379	1.391	1.402	1.426	1.449	1.472	1.496	1.519	1.542	1.566	1.589	1.612	1.635

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TABLE 4.- VALUES OF A_1/t_s FOR FLAT PANELS WITH Z-SECTION STIFFENERS HAVING

$$\frac{h_f}{h_w} = 0.4 \quad \text{(FROM REFERENCE 3) FOR USE AS VALUES OF } A_{1_{eq}}/t_{s_{eq}} \quad \text{WITH}$$
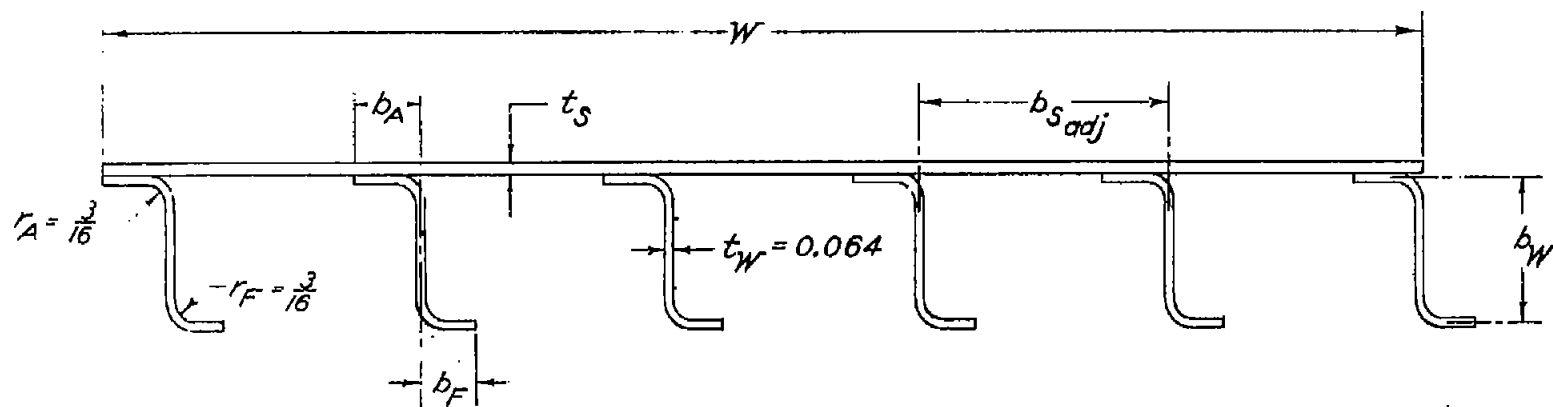
$$\text{DESIGN CHARTS FOR MG-AL PANELS HAVING } \frac{t_w}{t_{s_{eq}}} = 1.00$$

b_s/t_s \ b_w/t_w	20	21	22	23	24	25	26	27	28	29	30	32	34	36	38	40	42	44	46	48	50
25	2.327	2.383	2.439	2.495	2.551	2.607	2.663	2.719	2.775	2.831	2.887	2.999	3.111	3.223	3.335	3.447	3.559	3.671	3.783	3.895	4.007
26	2.276	2.330	2.383	2.437	2.491	2.545	2.599	2.653	2.706	2.760	2.814	2.922	3.030	3.137	3.245	3.353	3.460	3.568	3.676	3.783	3.891
27	2.228	2.280	2.332	2.384	2.436	2.488	2.540	2.591	2.643	2.695	2.747	2.851	2.954	3.058	3.162	3.265	3.369	3.473	3.577	3.680	3.784
28	2.185	2.235	2.285	2.335	2.385	2.435	2.485	2.535	2.585	2.635	2.685	2.785	2.885	2.985	3.085	3.185	3.285	3.385	3.485	3.585	3.685
29	2.144	2.192	2.240	2.289	2.337	2.385	2.433	2.482	2.530	2.578	2.626	2.723	2.820	2.916	3.013	3.109	3.206	3.302	3.399	3.495	3.592
30	2.106	2.152	2.199	2.246	2.292	2.339	2.386	2.432	2.479	2.526	2.572	2.666	2.759	2.852	2.946	3.039	3.132	3.226	3.319	3.412	3.506
31	2.070	2.115	2.160	2.205	2.251	2.296	2.341	2.386	2.432	2.476	2.522	2.612	2.702	2.792	2.882	2.973	3.063	3.154	3.244	3.334	3.425
32	2.036	2.080	2.124	2.168	2.211	2.255	2.299	2.343	2.386	2.430	2.474	2.561	2.649	2.736	2.824	2.911	2.999	3.086	3.174	3.261	3.349
33	2.005	2.048	2.090	2.132	2.175	2.217	2.260	2.302	2.344	2.387	2.429	2.514	2.599	2.684	2.769	2.854	2.938	3.023	3.108	3.193	3.278
34	1.975	2.017	2.058	2.099	2.140	2.181	2.223	2.264	2.305	2.346	2.387	2.470	2.552	2.634	2.717	2.799	2.881	2.964	3.046	3.128	3.211
35	1.948	1.988	2.028	2.068	2.108	2.148	2.188	2.228	2.268	2.308	2.348	2.428	2.508	2.588	2.668	2.748	2.828	2.908	2.988	3.068	3.148
36	1.921	1.960	1.999	2.038	2.077	2.116	2.155	2.194	2.232	2.271	2.310	2.388	2.466	2.544	2.621	2.699	2.777	2.855	2.932	3.010	3.088
37	1.896	1.934	1.972	2.010	2.048	2.086	2.123	2.161	2.199	2.237	2.275	2.350	2.426	2.502	2.578	2.653	2.729	2.805	2.880	2.956	3.032
38	1.873	1.910	1.946	1.983	2.020	2.057	2.094	2.131	2.168	2.204	2.241	2.315	2.389	2.462	2.536	2.610	2.683	2.757	2.831	2.904	2.978
39	1.850	1.886	1.922	1.958	1.994	2.030	2.066	2.102	2.138	2.174	2.209	2.281	2.353	2.425	2.497	2.568	2.640	2.712	2.784	2.856	2.927
40	1.829	1.864	1.899	1.934	1.969	2.004	2.039	2.074	2.109	2.144	2.179	2.249	2.319	2.389	2.459	2.529	2.599	2.669	2.739	2.809	2.879
42	1.790	1.823	1.856	1.890	1.923	1.956	1.990	2.023	2.056	2.090	2.123	2.190	2.256	2.323	2.390	2.456	2.523	2.590	2.656	2.723	2.790
44	1.754	1.786	1.817	1.849	1.881	1.913	1.945	1.976	2.008	2.040	2.072	2.136	2.199	2.263	2.327	2.390	2.454	2.517	2.581	2.645	2.708
46	1.721	1.751	1.782	1.812	1.843	1.873	1.904	1.934	1.964	1.995	2.025	2.086	2.147	2.208	2.269	2.330	2.391	2.451	2.512	2.573	2.634
48	1.691	1.720	1.749	1.778	1.808	1.837	1.866	1.895	1.924	1.953	1.983	2.041	2.099	2.158	2.216	2.274	2.333	2.391	2.449	2.508	2.566
50	1.663	1.691	1.719	1.747	1.775	1.803	1.831	1.859	1.887	1.915	1.943	1.999	2.055	2.111	2.167	2.223	2.279	2.335	2.391	2.447	2.503
52	1.638	1.665	1.692	1.719	1.746	1.772	1.799	1.826	1.853	1.880	1.907	1.961	2.015	2.069	2.122	2.176	2.230	2.284	2.338	2.392	2.446
54	1.614	1.640	1.666	1.692	1.718	1.744	1.770	1.796	1.822	1.848	1.873	1.925	1.977	2.029	2.081	2.133	2.185	2.236	2.288	2.340	2.392
56	1.592	1.617	1.642	1.667	1.692	1.717	1.742	1.767	1.792	1.817	1.842	1.892	1.942	1.992	2.042	2.092	2.143	2.192	2.242	2.292	2.342
58	1.572	1.596	1.620	1.644	1.668	1.693	1.717	1.741	1.765	1.789	1.813	1.861	1.910	1.958	2.006	2.055	2.103	2.151	2.199	2.248	2.296
60	1.553	1.576	1.599	1.623	1.646	1.669	1.693	1.716	1.739	1.763	1.786	1.833	1.879	1.926	1.973	2.020	2.066	2.113	2.160	2.206	2.253
65	1.510	1.532	1.553	1.575	1.596	1.618	1.639	1.661	1.683	1.704	1.726	1.769	1.812	1.855	1.898	1.941	1.984	2.027	2.070	2.113	2.156
70	1.474	1.494	1.514	1.534	1.554	1.574	1.594	1.614	1.634	1.654	1.674	1.714	1.754	1.794	1.834	1.874	1.914	1.954	1.994	2.034	2.074
75	1.442	1.461	1.480	1.498	1.517	1.536	1.554	1.573	1.592	1.610	1.629	1.666	1.704	1.741	1.778	1.816	1.853	1.890	1.928	1.965	2.002

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Figure 1.-　Mg-Al panel in testing machine.

W

b_A t_S $b_{s_{adj}}$

$r_A = \frac{3}{16}$

$t_W = 0.064$

b_W

$r_F = \frac{3}{16}$

b_F

Figure 2.— Cross section of test specimens.
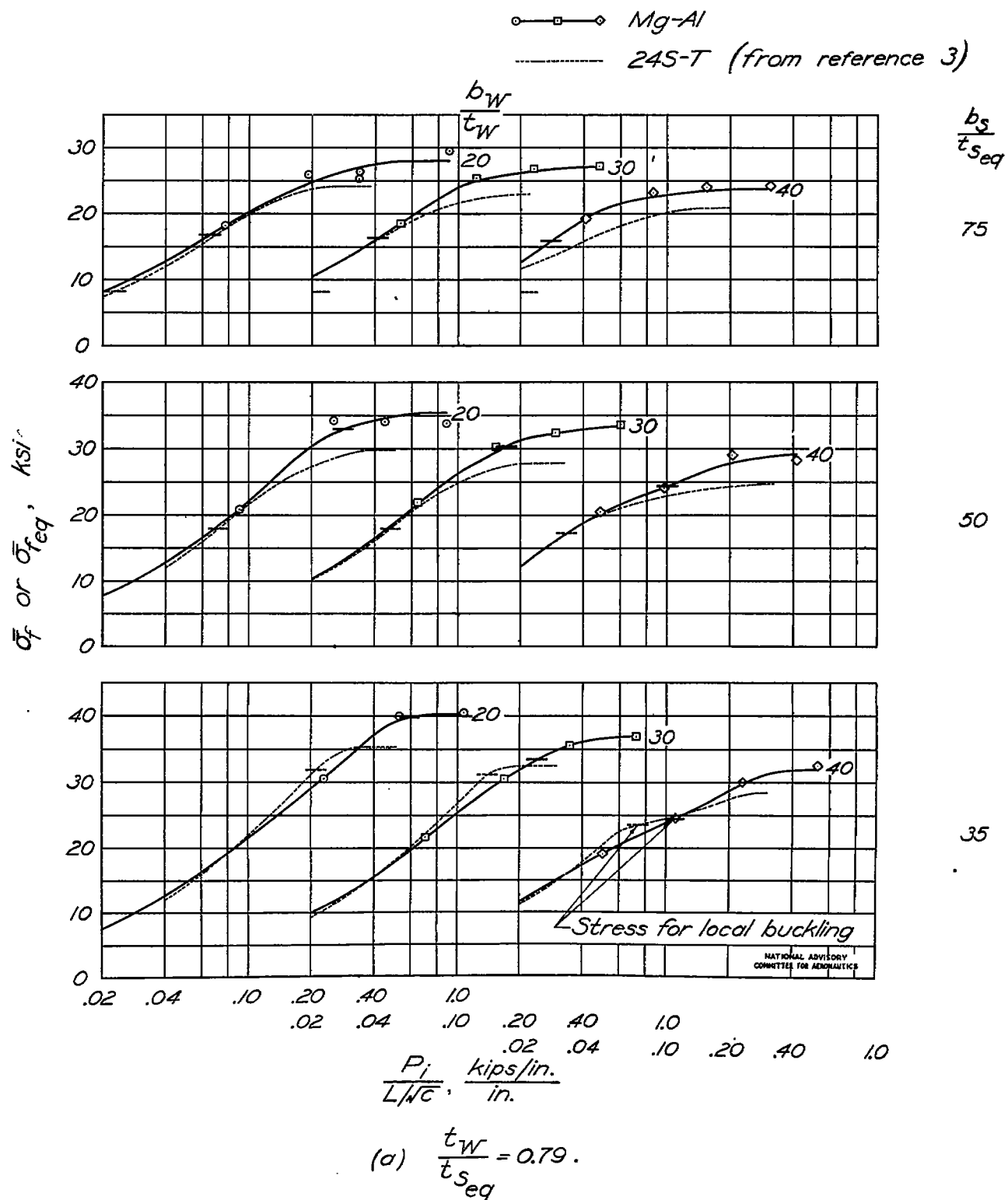
Fig. 2

(a) $\dfrac{t_W}{t_{S_{eq}}} = 0.79$.

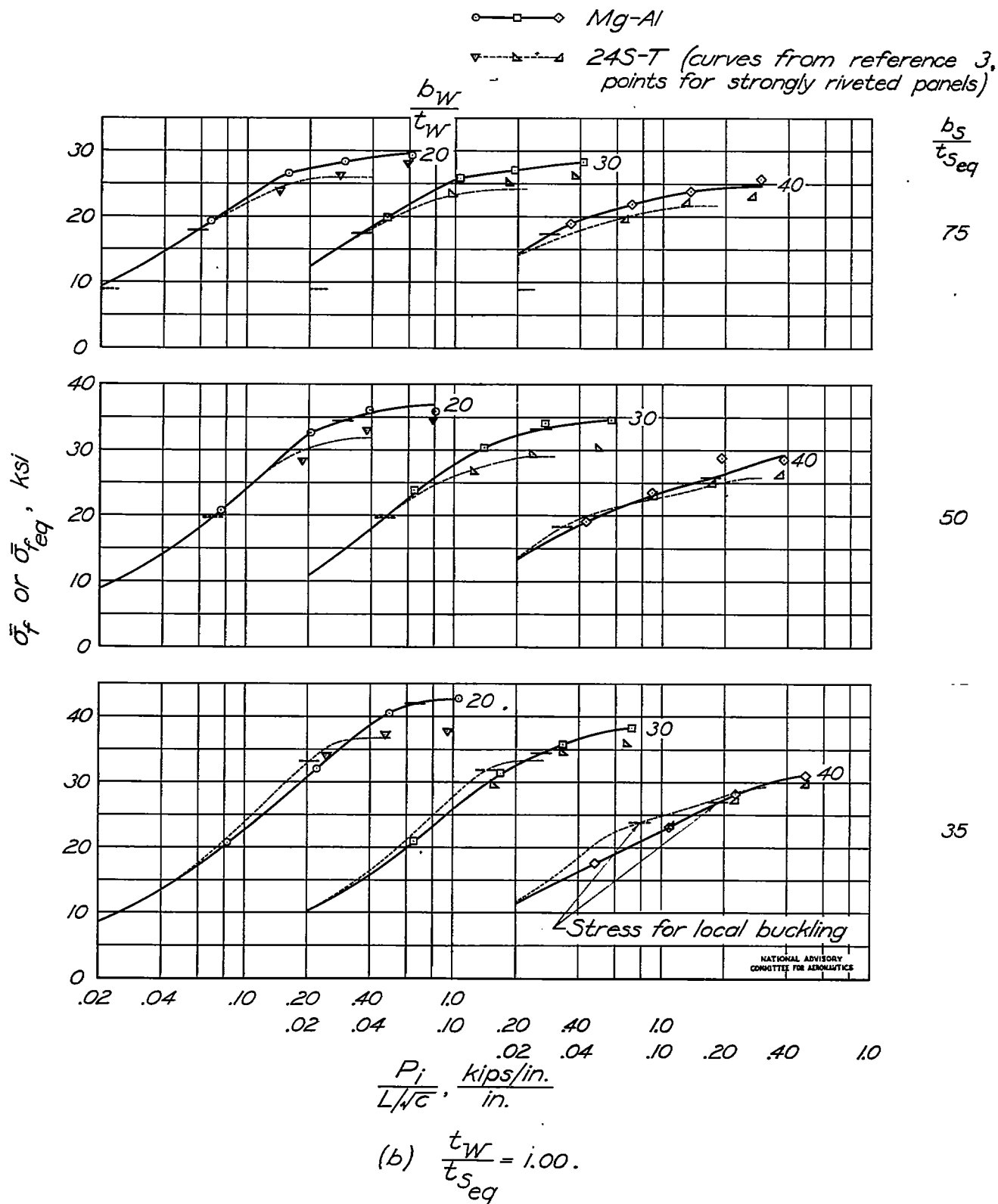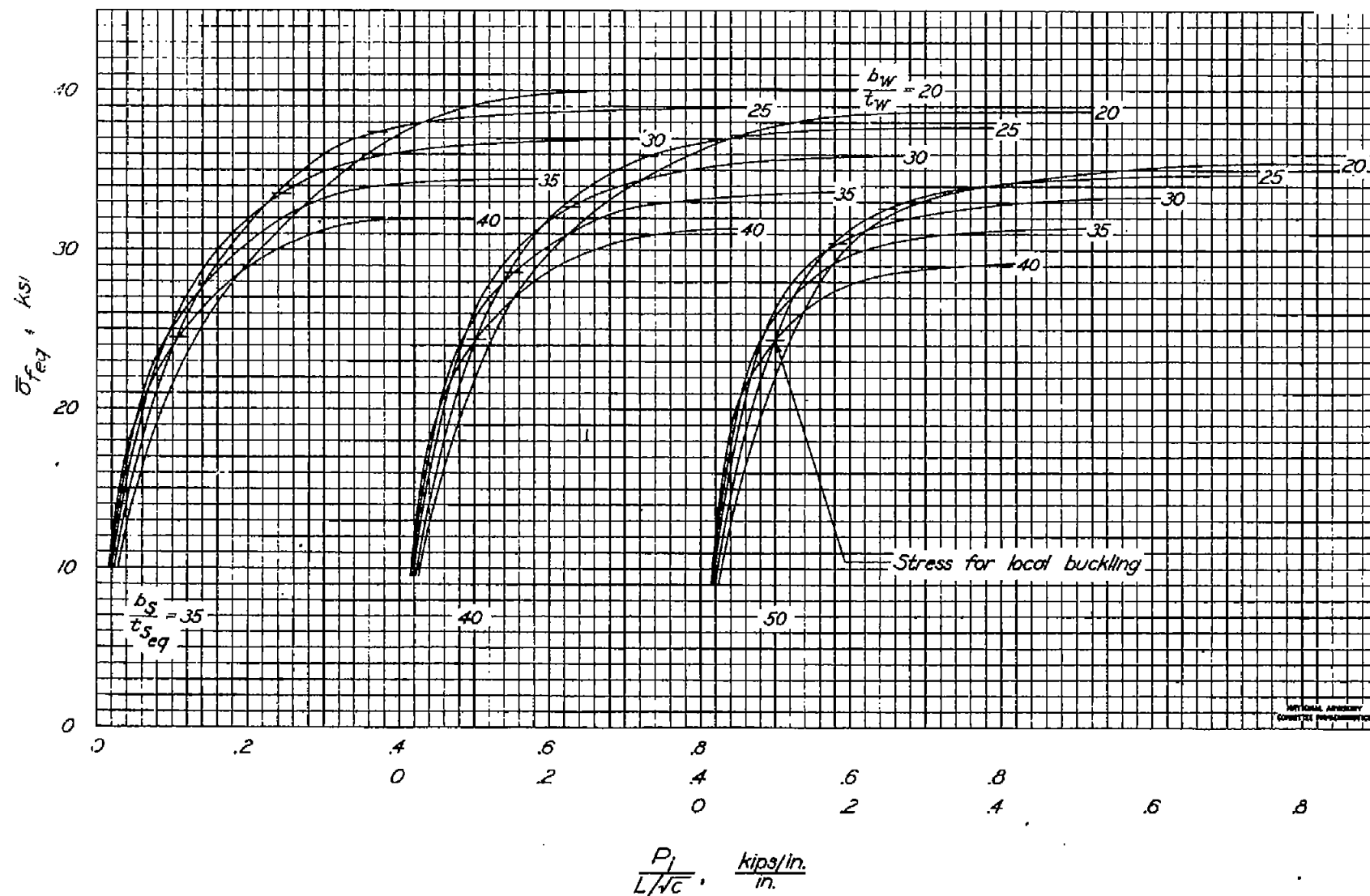Figure 3.- Comparison of 24S-T and Mg-Al panels of the proportions tested.

Figure 3. - Concluded.

Fig. 4

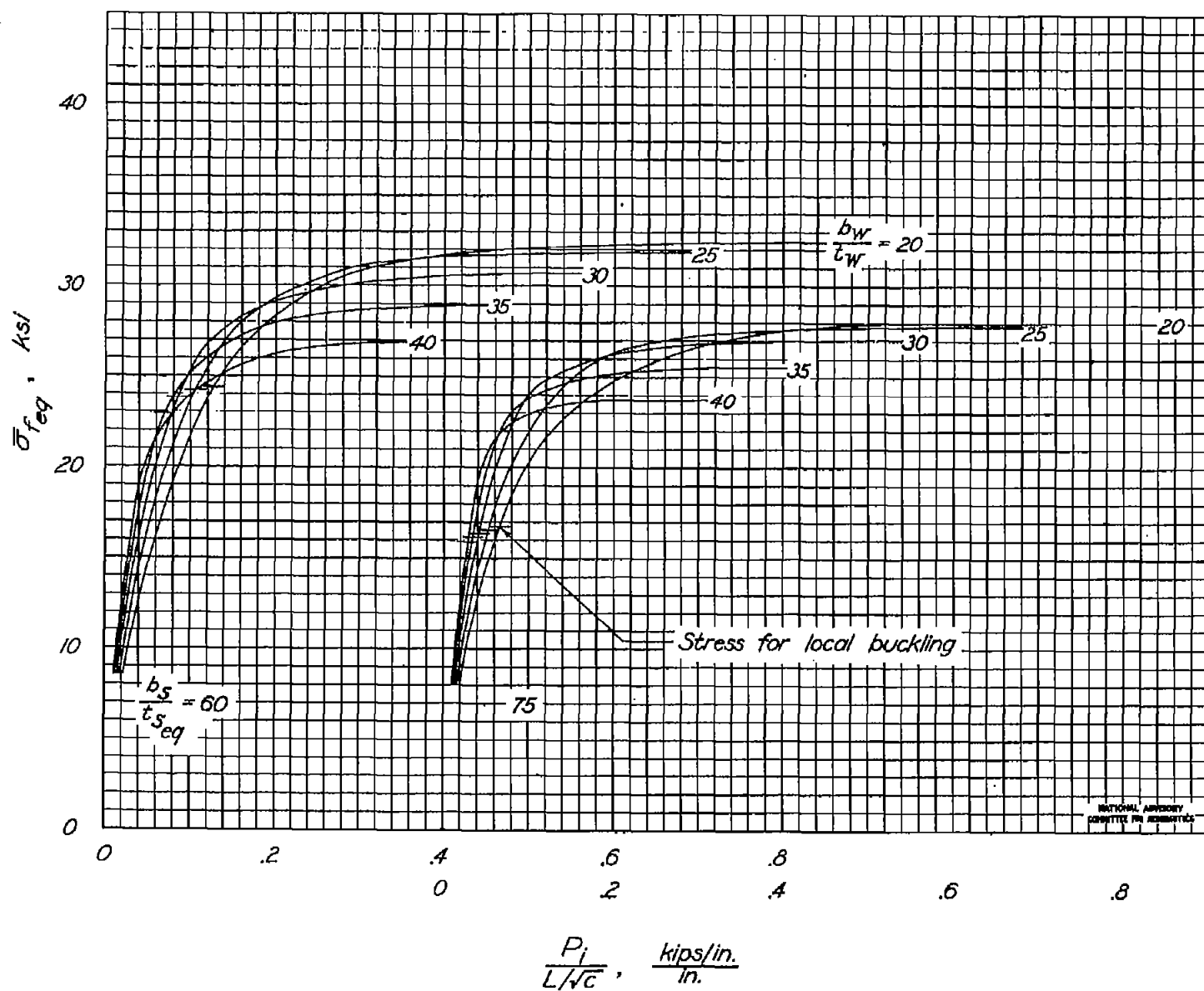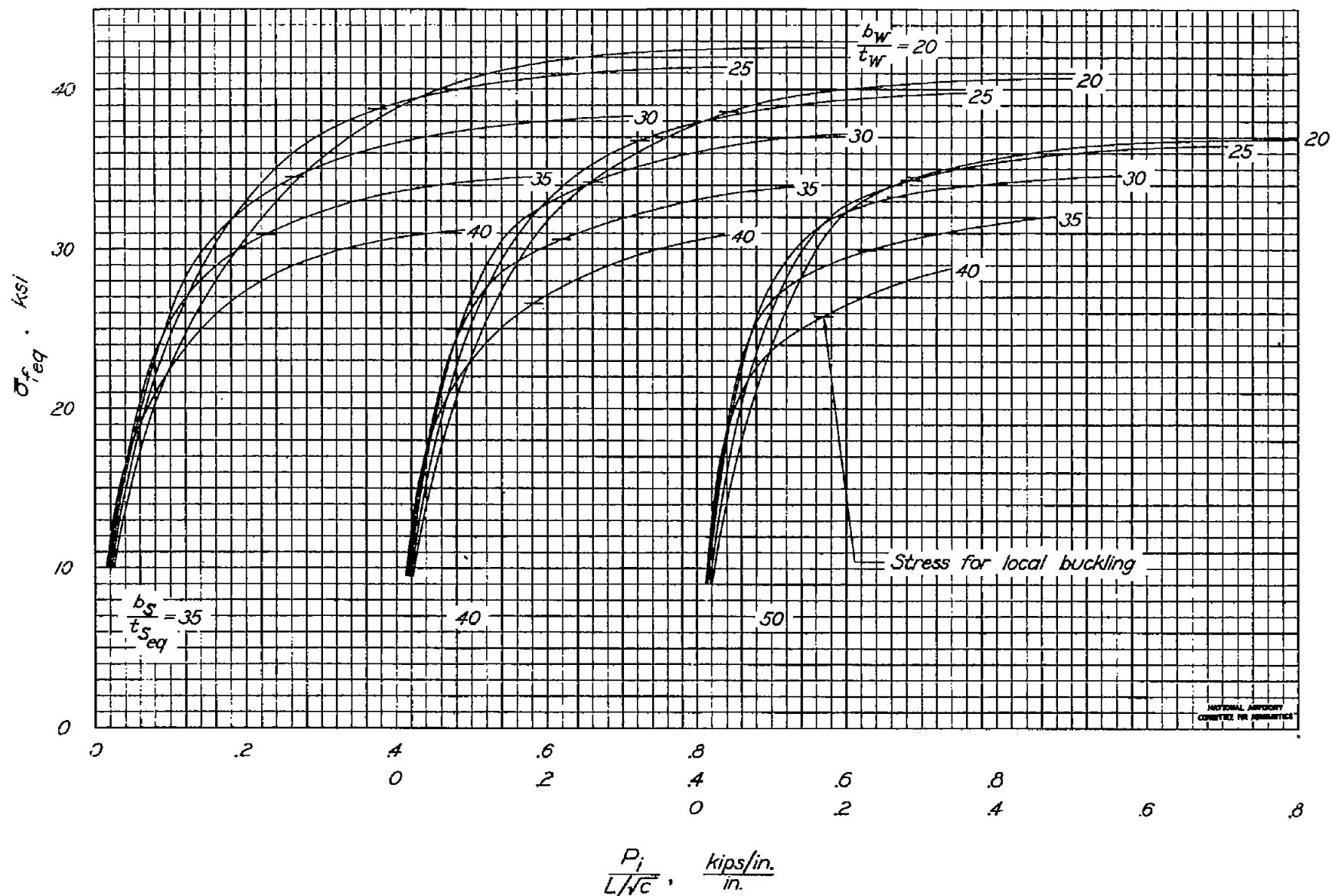Figure 4. - Design chart for Mg-Al panels of the type tested and having $\dfrac{t_W}{t_{S_{eq}}} = 0.79$.

Fig. 4 conc.

Figure 4. – Concluded.

Fig. 5

Figure 5. - Design chart for Mg-Al panels of the type tested and having $\dfrac{t_W}{t_{S_{eq}}} = 1.00$.
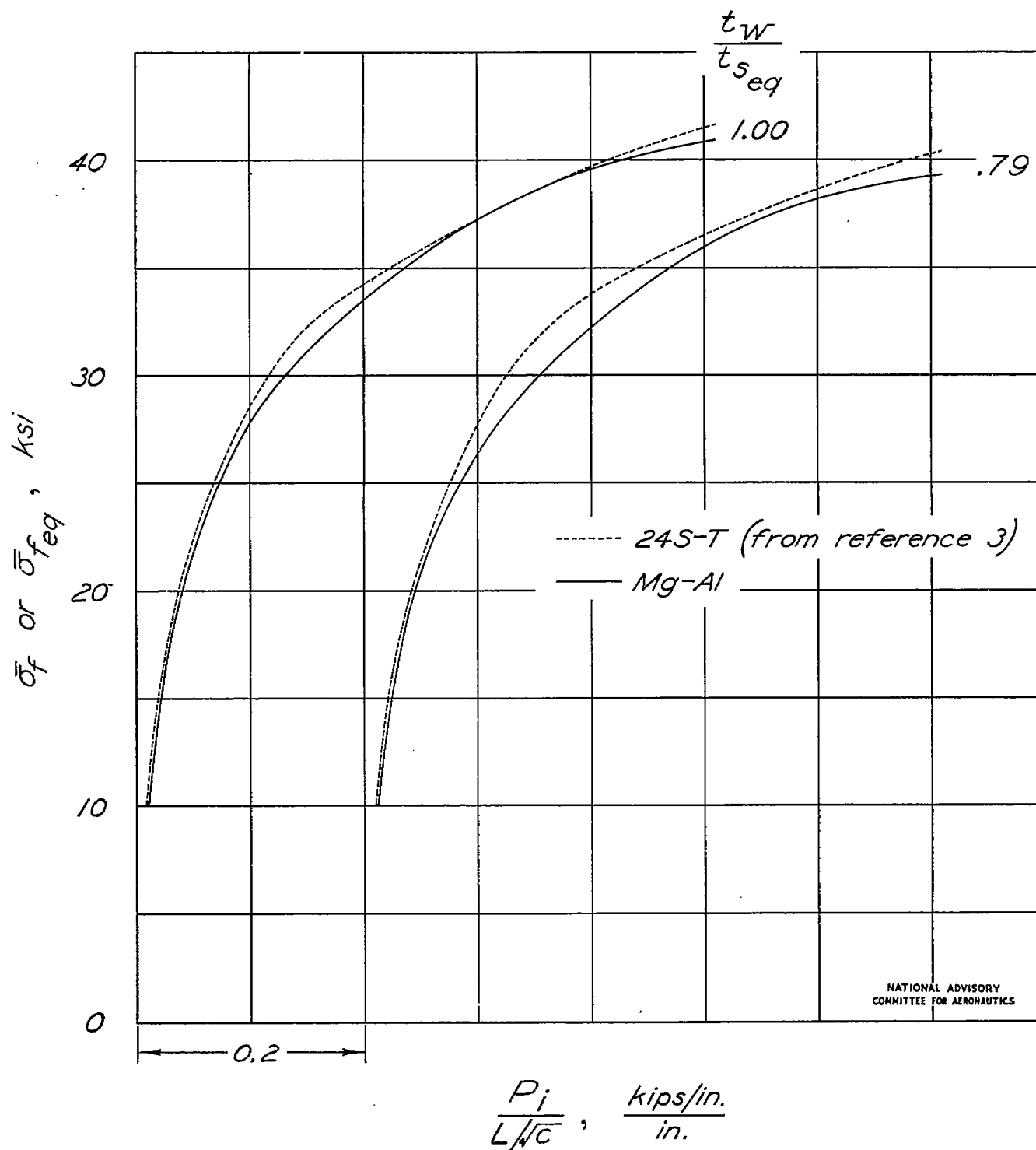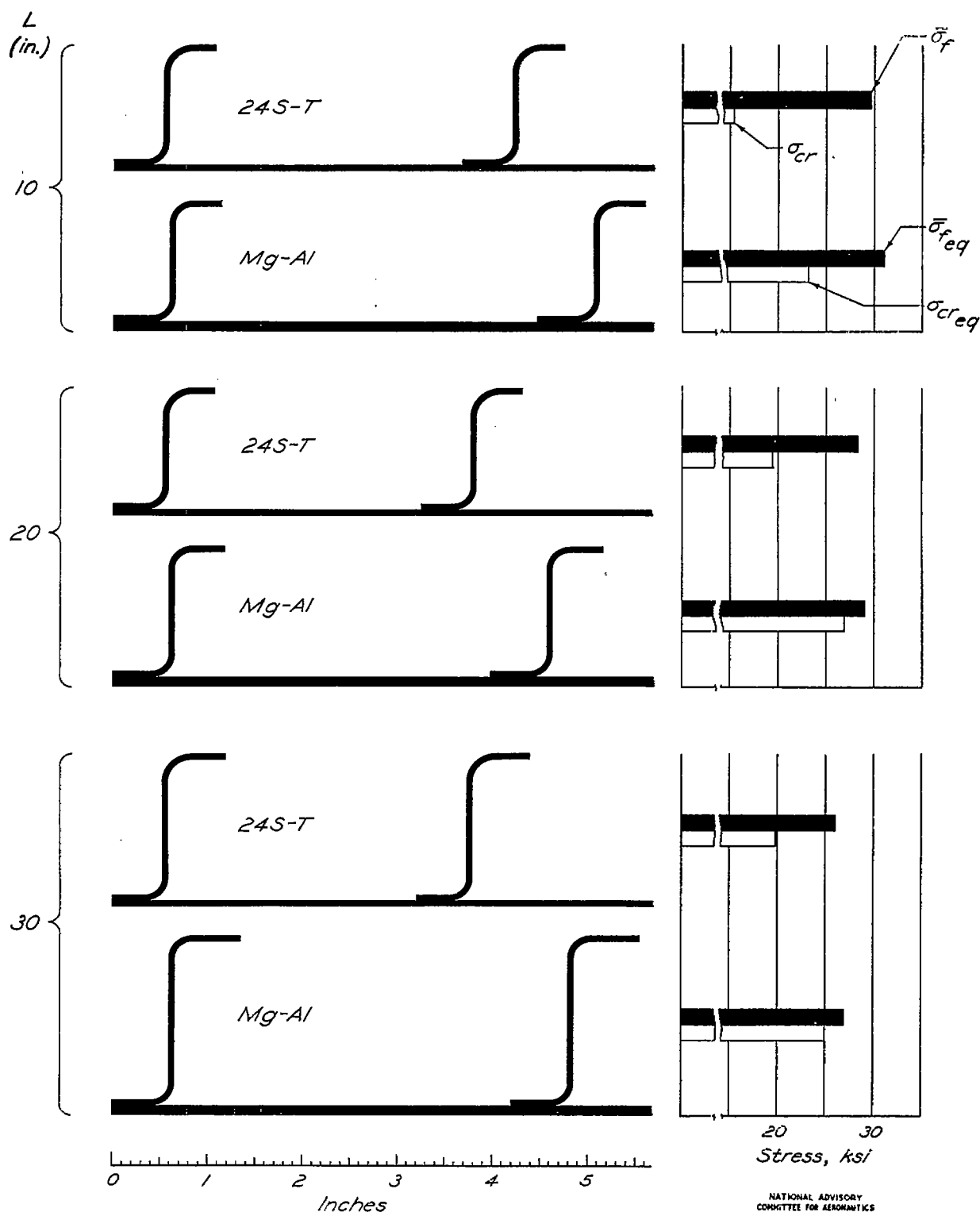
Fig. 5 conc.
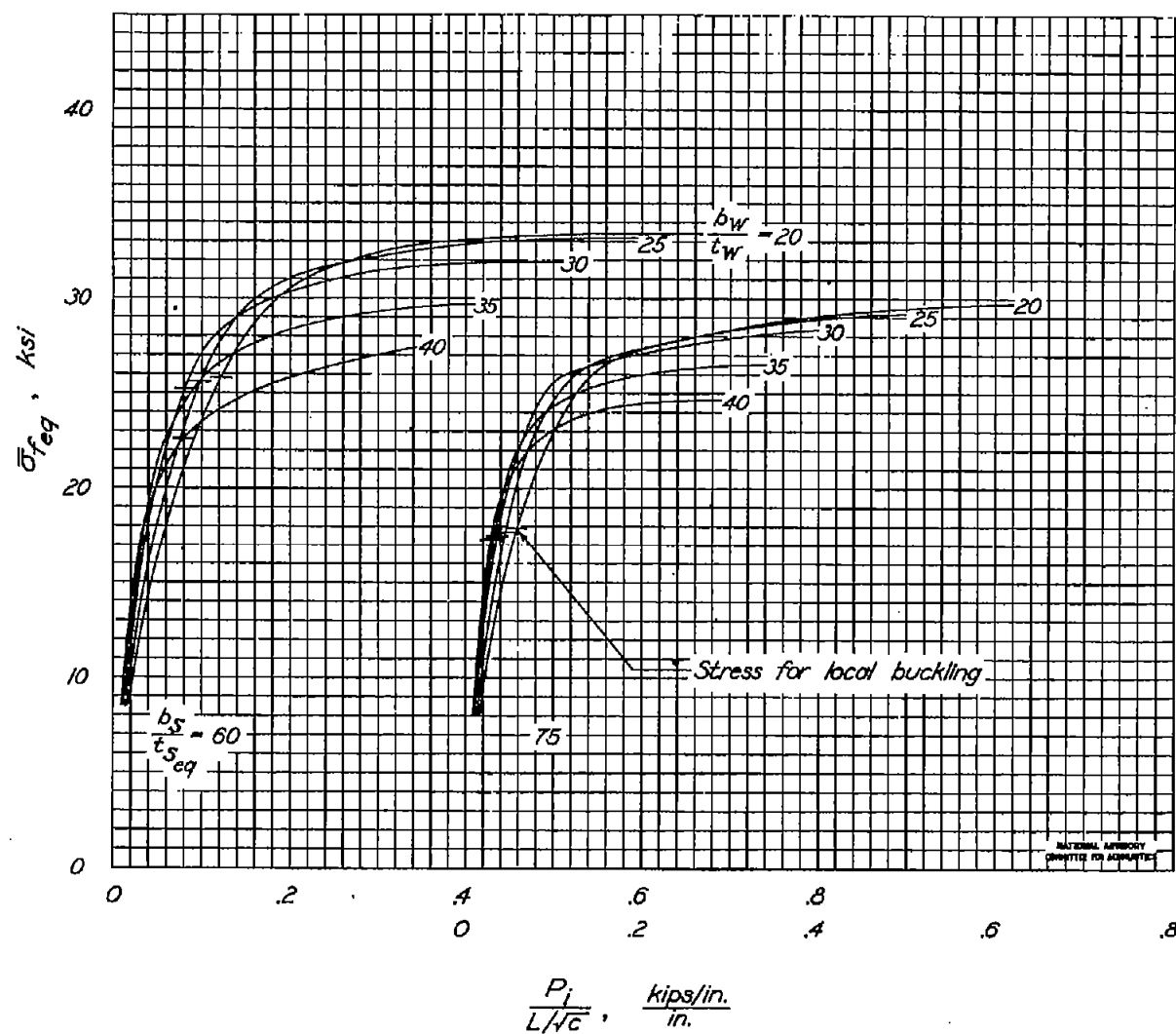
Figure 5.- Concluded.

Fig. 6   NACA TN No. 1274

Figure 6.- Comparison of 24S-T and Mg-Al panels
of ideal proportions.

Figure 7.— Comparison of 24S-T and Mg-Al panels of the
proportions required for the minimum-weight design for
$P_i = 3.0$ kips/inch; $c = 1$; $t_{S_{eq}} = 0.064$ inch.

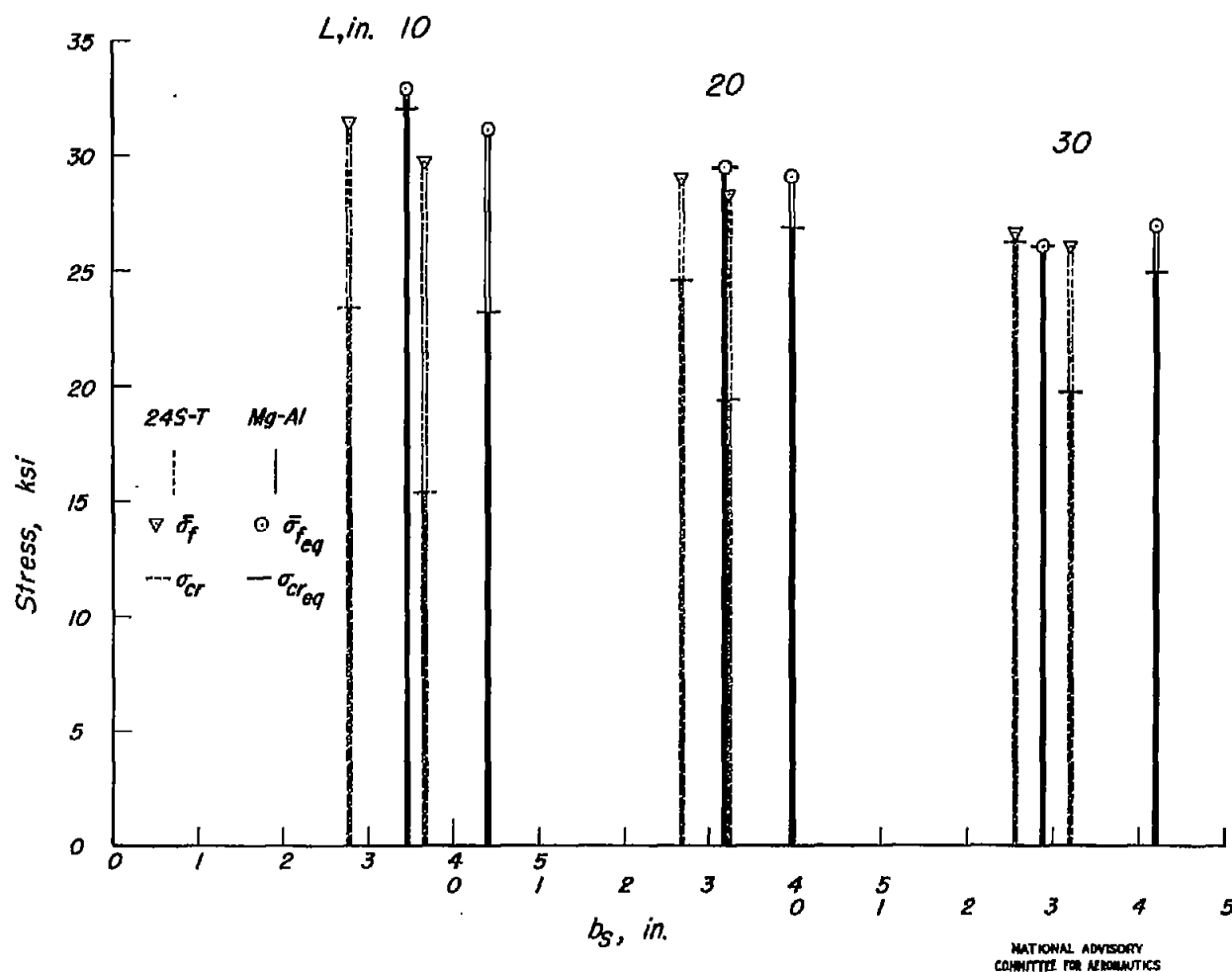(b) $\dfrac{t_w}{t_{s_{eq}}} = 1.00$.

Figure 7.– Concluded.

Figure 8.- Comparison of stiffener spacing, buckling stress, and average stress at failing load for minimum-weight designs of 24S-T and Mg-Al panels, $P_i = 3.0$ kips/inch; $c = 1$; $t_{s_{eq}} = 0.064$ inch.

Fig. 8